ENGINEERING SHOP WORK

By W. A. KNIGHT, *Professor of Mechanical Practice*

In the report on a Study of Engineering Education by Chas. E. Mann, made after a somewhat lengthy and thorough investigation, this statement occurs: "There is no agreement as to the purpose and methods of shop work. Nearly every school has a shop philosophy of its own."

It would seem that there should be no great divergence of opinion as to the purpose, at least, of shop work. This, stated as briefly as possible, is to give the engineer a working knowledge of the nomenclature, tools and methods used in the different shop processes. If a student engineer is put into the foundry, certainly he is not put there to study Art, Language or Mathematics—but to learn foundry practice. Incidentally, other results may be sought for, such as development of judgment, skill, initiative and self-reliance, which taken together simply mean increased capacity for doing things. He may, and does on occasion, find some application of physics or mathematics or absorb some ideas of shop management, but the primary purpose is to give him as much knowledge as possible of the tools, appliances, materials and methods used in productive foundry practice.

Many, and excellent, conditions of an engineer have been given, but it suits my purpose here to define an engineer as one who *directs the operations and processes by which raw material is converted into useful products.* Transportation, the harnessing and transmission of power, operation of machines are but incident to the main purpose, which is that of making nature's great stores of raw materials available for the uses of mankind. This is fundamentally the work of the engineer. All of his efforts, his knowledge and his creative conceptions lead finally to some phase of this transformation. Granting this, a little consideration will show that, although the methods and processes by which the transformations are effected are varied in the extreme, there is yet a certain continuity running through the entire range of effort. Each process is but a continuation of the preceding, a link in the chain of events by which material is transformed from its initial condition to its final stage of completion. The Mining Engineer is concerned with getting out ore and fuel. These, stored in the bowels of the earth, are his raw material, loaded onto cars, his final product. The work is here taken up by the Metallurgical Engineer. The ore which is his raw material undergoes a further transformation resulting in ingot metal, billets, bars and sheets. But ingot metal, bars and sheets would be of little service without means of further conversion and it is to the shop methods and processes that we must look to find these. Ingot metal is the raw material of the foundry. Castings of various kinds are its finished products. These, in turn, together with bar metal, sheets and products of the forge shop, become the raw material of the machine shop. Thus the work is carried along from one stage to another, always undergoing changes that bring it one step nearer its ultimate goal. While each branch of engineering has its own particular field and its own problems to solve, yet it cannot escape being concerned with all others. No engineer can work intelligently unless he knows for what purpose his product is intended, what the requirements are, how well it fulfills them, and the characteristics of his raw material. He must reach out and try to understand the problems of the man ahead of him and look back, with a sympathetic understanding, to the problems of the man behind him. In proportion as he can do this will he be successful in solving the problems that arise in his own field. The radius of action of the engineer must be much greater than that of the mechanic, as that of the mechanic is greater than the machine operator.

If you can, let your imagination go back to early November, 1918, let it travel to the spruce forests of Oregon and Washington, to the iron mines of Minnesota, to the copper mines of Michigan and Montana, the oil fields of Texas, the coal mines of Virginia, to other sources of raw material and to the network of transportation lines spanning the country. Watch this material gravitating toward the shops. Watch it emerge in the form of airplanes, motor vehicles, locomotives, battleships, guns and munitions, instruments of precision and other articles of infinite extent and variety, and thread its way toward the Atlantic seaboard. Wonderful transformation! Controlled and directed all along the line by Engineers. The unity of purpose and effort is no less marked in times of peace than in times of war.

Why does the engineer study Physics? That he may understand, control and direct the forces of nature. Why does he study Chemistry? That he may know the innermost secrets of material. Why does he study the strength of materials? That he may know of their physical properties. But, above all, why does he wish to control the forces of nature, to know the innermost secrets of material, their physical properties and methods by which they are transformed from one condition to another? Simply that he may take part in and become an intelligent directing factor in the great transformation of raw materials into useful products. By no means the least of the transformations in variety, extent and in the requirements of knowledge, skill and resourcefulness are those which take place in the four fundamental engineering shops, i. e., Wood, Forge, Foundry and Machine Shop. These shops form the great clearing house thru which the bulk of material must pass before becoming serviceable. How they have developed and kept pace with growing demands is evidenced by our ability to fabricate all kinds of material into intricate mechanism with a speed and precision that is truly remarkable. It is a far cry from the work of a savage, laboriously rubbing two stones together to fashion a rude implement, to the work of our multispindle automatic machines of today. So it is from lugging a skinfull of ore to the bloomery forge on the

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hillside to the loading, from the mine, of a 13,000 ton ship in 30 minutes. But the early savage who first attempted to form, from nature's raw materials, some useful implements—implements that would assist them in maintaining the eternal struggle for existence, were the pioneer engineers. His tribe has increased, his knowledge extended, his methods and processes developed until today there is no material in the earth or in the air but yields obedience to his desires.

For what purpose, then, do we put the young engineer in the shops? Is it to rub elbows with his fellow workmen to get their viewpoints? Is it to earn money? Is it to develop skill and judgment? Is it to teach him the handling of men or shop management? No, it is neither of these. The purpose is to give him as thorough a knowledge as possible, in the time available, of the tools, appliances, materials and methods of productive shop practice. To enable him to get first-hand information of some of the more important steps thru which material must pass, as it progresses from its initial to its final stages of completion. It is not contended that no attention should be paid to the other phases of the subject. They are all valuable and should be made to supplement the work whenever possible, yet they are but satellites revolving around the main purpose.

This conception of shop work at once quenches the idea that its purpose is satisfied when the student is allowed a little indiscriminate practice with tools, or that the work should be made "interesting" by allowing him to make little knick-knacks that can be taken home with him. That kind of work is worse than nothing, for it tends to encourage the tinkering habit and divert the student's mind from the real problems of the engineer. In the Forge shop, for instance, it is vastly more important for the student to learn something of the flow of metals under the hammer, behavior of different kinds of steel, effects of working too hot or too cold, faults likely to develop during the progress of forging, conditions essential for a perfect weld, the purpose, effect and methods of annealing, hardening and heat treatment, than it is for him to make an ornamental lamp. Neither is the purpose satisfied when the student is allowed to pick up his shop experience at random in commercial shops. It is just as logical to expect him to pick up his drawing, chemistry and other laboratory work in the same way.

Shopwork is fundamental and vital to engineering progress. It covers an enormous field and one that touches every phase of engineering activity. In the application of scientific knowledge we can go as far and as fast as our shop methods develop—no farther and no faster. It is a field that has scope enough and can utilize the best brains of the engineering profession.

In the engineering industries today there are too few men with thorough understanding of fundamental processes of shop work. Too much "passing the buck" down along the line by those who should know. Too many impractical ideas sent into the shops. Under the older shop management where the executives, from the general manager down, were men who came up from the ranks, the problem was one not of production, but of salesmanship. Today it is not a problem of salesmanship but one of production. With modern methods and subdivisions of labor it is illogi-

cal to look to machine operators for a solution of the problems that arise in production. Subdivision of labor throws more, not less, responsibility on the directing forces. Instead of lessening the technically trained man's need for a thorough understanding of shop methods, this subdivision has increased it. Not only that, but it has made it increasingly difficult for an undergraduate to get outside shop experience of any value. There is now practically no opportunity, outside, for forge, foundry or pattern work. There is yet some for machine work, but even this is much restricted. It is hardly to be expected that manufacturers will take in temporary help during vacation periods and give training along any but very narrow lines. Often this is confined to the teaching of a single operation. Neither is it fair to the student to expect him to go into the industries for practical experience without at least some little preparation. That is placing too much of a burden on the student and the manufacturer.

There is a tendency in some quarters to belittle shop work, to crowd it back, out altogether, or to "tolerate it" as expressed in the Mann Report. It is dirty and greasy and, a priori, has no moral or intellectual value. However, "dirty hands and a clean heart are far preferable to clean hands and a dirty heart." Character can be developed at the lathe or forge as well as in the class room. Neither is inspirational teaching necessarily associated with a white collar. The work of the college shops has, in the past, more than justified their existence. Changed conditions in our industries furnish a more logical reason and a greater need for this work in our engineering curricula than ever before. There should be a new spirit and a new era of development in our college shop work.